10.0 GUIDANCE FOR PERFORMING TIER II EVALUATIONS

10.1 Tier II: Water Column Effects

If a water column determination cannot be made in Tier I, the Tier II water column evaluation must be conducted for comparison with numeric water-quality standards (WQS) (Section 5.1). There are two approaches for the Tier II water column evaluation for WQS compliance. One approach is to use numerical models provided in Appendix C of this manual as a screen, assuming conservatively that all of the contaminants in the dredged material are released into the water column during the disposal process. The other approach applies the same model, using the results from a chemical analysis of an elutriate prepared from the dredged material (Section 10.1.2.1).

10.1.1 Screen Relative To WQS

A screening approach may reduce the evaluation effort for dredged material that will cause only minimal water column impact. In a typical disposal operation, most contaminants remain associated with the dredged material that settles to the bottom and cause limited water column impact during descent. The screen is not a requirement but is intended to reduce the effort required to develop information required for factual determinations.

Appendix C provides guidance on which numerical computer or analytical models should be applied to particular dredged material disposal projects and the information that is necessary to perform the evaluations. Versions of models for use on IBM-compatible microcomputers and example applications are provided on the diskettes in the pocket inside the back cover of this manual. The output of the appropriate model is used to determine if additional testing is needed.

The model need be run only for the contaminant of concern that requires the greatest dilution. If this contaminant is shown to meet the WQS, all of the other contaminants that require less dilution will also meet the WQS. The contaminant requiring the greatest dilution is determined by calculating the dilution that would be required to meet the WQS. To determine the dilution *D,* the following equation is solved for each contaminant of concern in terms of dissolved concentrations:

$$D = [(C_s \times SS/1000) - C_{wq}] / (C_{wq} - C_{ds})$$

where C_s = concentration of the contaminant in the dredged material expressed as micrograms per kilogram (µg/Kg), on a dry weight basis;

SS	=	suspended solids concentration in the dredged material discharge expressed as grams per liter (g/L);
1000	=	conversion factor, g to Kg;
C_{wq}	=	WQS in micrograms per liter (µg/L); and
C_{ds}	=	background concentration of the contaminant at the disposal site in micrograms per liter (µg/L).

Note that if the concentration of the constituent in the dredged material (C_s x SS/1000) is less than C_{wq}, no calculation is necessary since no dilution is required. Note also that, if the ambient disposal-site water concentration (C_{ds}) of a constituent is greater than C_{wq}, water quality at the disposal site cannot be met by dilution. Appendix C provides detailed information for performing the above calculations and identifying the contaminant of concern requiring the greatest dilution.

The concentration of this contaminant is then modeled to determine its maximum concentration in the water column outside the boundary of the mixing zone. If this concentration is below the applicable WQS, no additional testing is necessary to make a determination regarding WQS. If the concentration is higher, additional testing is necessary, as described in Section 10.1.2.

Note that the procedure described above cannot be used to evaluate water column impact. It can be used *only* to determine whether additional testing for potential water-column impact, as described in Section 10.1.2, is necessary.

10.1.2 Elutriate Analysis Relative To WQS

For an elutriate analysis, the numerical mixing model (Appendix C) is run with chemical data obtained from an elutriate test conducted on the dredged material. The standard elutriate analysis is described in Section 10.1.2.1 and the analytical procedures for measuring constituents in the water are provided in Section 9.4.2. The model is, in effect, using data that more accurately represent the contaminant concentrations that will be present in the water column after consideration of mixing. If the numerical model (Appendix C) predicts that the concentration of all contaminants of concern at the edge of the mixing zone is less than the available, applicable WQS, the dredged material complies with WQS. Otherwise, it does not.

10.1.2.1 Standard Elutriate Preparation

The standard elutriate test is used to predict the release of contaminants to the water column resulting from open water disposal. Prior to use, all labware should be thoroughly cleaned as appropriate for the contaminant analysis. At a minimum, labware should be washed with detergent, rinsed with acetone, five times with tap water, placed in a clean 10% HCl acid bath for a minimum of 4 h, rinsed five times with tap water, and then thoroughly flushed with either distilled or deionized water.

The elutriate should be prepared by using water from the dredging site. Enough elutriate should be prepared for the chemical analyses and for the water column toxicity tests in Tier III.

The elutriate is prepared by subsampling approximately 1 L of the dredged material from the well-mixed original sample. The dredged material and unfiltered water are then combined in a sediment-to-water ratio of 1:4 on a volume basis at room temperature (22 ± 2°C). This is best accomplished by volumetric displacement. After the correct ratio is achieved, the mixture is stirred vigorously for 30 min with a mechanical or magnetic stirrer. At 10 min intervals, the mixture is also stirred manually to ensure complete mixing. After the 30 min mixing period, the mixture is allowed to settle for 1 h. The supernatant is then siphoned off without disturbing the settled material, and centrifuged to remove particulates prior to chemical analysis (approximately 2,000 rpm for 30 min, until visually clear). If the elutriate is to be used for toxicity testing, refer to the procedures in Section 11.1.4.

10.1.2.2 Chemical Analysis

Analytical procedures for specific constituents in water are provided in Section 9.4.2.

10.1.2.3 Comparison with WQS (Standard Elutriate Test)

The model need be run only for the contaminant that requires the greatest dilution to make a WQS determination. This contaminant may or may not be the same as that run in the screen (Section 10.1.1). Calculations must therefore be conducted for all of the contaminants detected during analysis of the elutriate to determine which one requires the greatest dilution. The contaminant requiring the greatest dilution is determined by calculating the dilution that would be required to meet the WQS. To determine the dilution D, the following equation is solved for each contaminant of concern in terms of dissolved concentrations:

$$D = (C_e - C_{wq})/(C_{wq} - C_{ds})$$

C_e = concentration of the dissolved contaminant in the standard elutriate in micrograms per liter (µg/L). All other terms are as previously defined in Section 10.1.1.

10.2 Theoretical Bioaccumulation Potential (TBP) of Nonpolar Organic Chemicals

The TBP is an approximation of the equilibrium concentration in tissues if the dredged material in question were the only source of contaminant to the organisms. The TBP calculation in Tier II is applied as a coarse screen to predict the magnitude of bioaccumulation likely to be associated with nonpolar organic contaminants in the dredged material. At present the TBP calculation can be performed only for nonpolar organic chemicals such as PCBs. However, methods for TBP calculations with metals and polar organic compounds are under development and may be added to this manual in the future. For the present, bioaccumulation potential of polar organic compounds, organometals, and metals in dredged material can only be tested (in Tiers III or IV), not calculated. However, it is still useful to calculate the TBP, which provides an indication of the magnitude of bioaccumulation of nonpolar organic compounds that may be encountered in testing at higher tiers. Additionally, if the TBP of the nonpolar organic compounds indicates that these contaminants are not bioavailable, this calculation may eliminate the need for further evaluation of these compounds and thereby reduce efforts in higher tiers.

Nonpolar organic chemicals include all organic compounds that do not dissociate or form ions. This includes the chlorinated hydrocarbon pesticides, many other halogenated hydrocarbons, PCBs, many PAHs including all the priority pollutant PAHs, dioxins and furans. It does not include metals and metal compounds, organic acids or salts, or organometallic complexes such as tributyltin or methyl mercury.

The environmental distribution of nonpolar organic chemicals is controlled largely by their solubility in various media. Therefore, in sediments they tend to occur primarily in association with organic matter (Karickhoff, 1981). In organisms they are found primarily in the body fats or lipids (Konemann and van Leeuwen, 1980; Geyer et al., 1982; Mackay, 1982; Bierman, 1990). Bioaccumulation of nonpolar organic compounds from dredged material can be estimated from the organic carbon content of the material, the lipid content of the organism, and the relative affinities of the chemical for sediment organic carbon and animal lipid content.

The TBP calculation assumes that various lipids in different organisms and organic carbon in different sediments are similar and have similar distributional properties. Other simplifying assumptions are that chemicals are freely exchanged between the sediments and tissues and that compounds behave

conservatively. In reality, compound size and structure may influence accumulation, and portions of organic compounds present on suspended particulates may have kinetic or structural barriers to availability. Another important assumption implicit in the TBP calculations is that there is no metabolic degradation or biotransformation of the chemical. Organic-carbon normalized contaminant concentrations are used such that the sediment-associated chemical can be characterized as totally bioavailable to the organism. Calculations based on these assumptions yield an environmentally conservative TBP value for the dredged material if the dredged material in question is the only source of the contaminant for the organism. However, note that TBP calculations are not valid for sediments with TOC $\leq$ 0.2%.

It is possible to relate the concentration of a chemical in one phase of a two-phase system to the concentration in the second phase when the system is in equilibrium. The TBP calculation focuses on the equilibrium distribution of a chemical between the dredged material or reference sediment and the organism. By normalizing nonpolar organic chemical concentration data for lipid content in organisms, and organic carbon in dredged material or reference sediment, it is possible to estimate the preference of a chemical for either phase. This approach is based on the work of Konemann and van Leeuwen (1980) and Karickhoff (1981).

McFarland (1984) took the approach one step farther. He calculated that the equilibrium concentration of nonpolar organic chemicals, which the lipids of an organism could accumulate as a result of exposure to dredged material, would be about 1.7 times the organic carbon-normalized concentration of the chemical in the dredged material. Concentrations are directly proportional to the lipid content of the organism and the contaminant content of the dredged material or reference sediment, and are inversely proportional to the organic carbon content of the dredged or reference material (Lake et al., 1987).

The possible chemical concentration in an organism's lipids [the lipid bioaccumulation potential (LBP)] would theoretically be 1.7 times the concentration of that chemical in the sediment organic carbon. Rubinstein et al. (1987) have shown, based on field studies with PCBs, that a value of 4 for calculating LBP is appropriate. However, note that more precise values for specific chemicals are now available. Current information on such values may be obtained from the ACOE Contaminated Sediment Bulletin Board (BBS: phone number is 601-634-4380; settings are N, 8, 1). LBP represents the potential contaminant concentration in lipid if the sediment is the only source of that contaminant to the organism. It is generally desirable to convert LBP to whole-body bioaccumulation potential for a particular organism of interest. This is done by multiplying LBP by that organism's lipid content, as determined by lipid analysis or from reported data. Soft-bodied invertebrate lipid contents may range from 1 - 2% wet weight (based on data from an oligochaete, midge, and amphipod species [G. Ankley, EPA Duluth and H. Lee, EPA Newport, pers. comm.]).

Theoretical bioaccumulation potential (TBP) can be calculated relative to the biota sediment accumulation factor (BSAF) as

$$TBP = BSAF\ (C_s / \%TOC)\ \%L$$

where TBP is expressed on a whole-body wet-weight basis in the same units of concentration as C_s, and

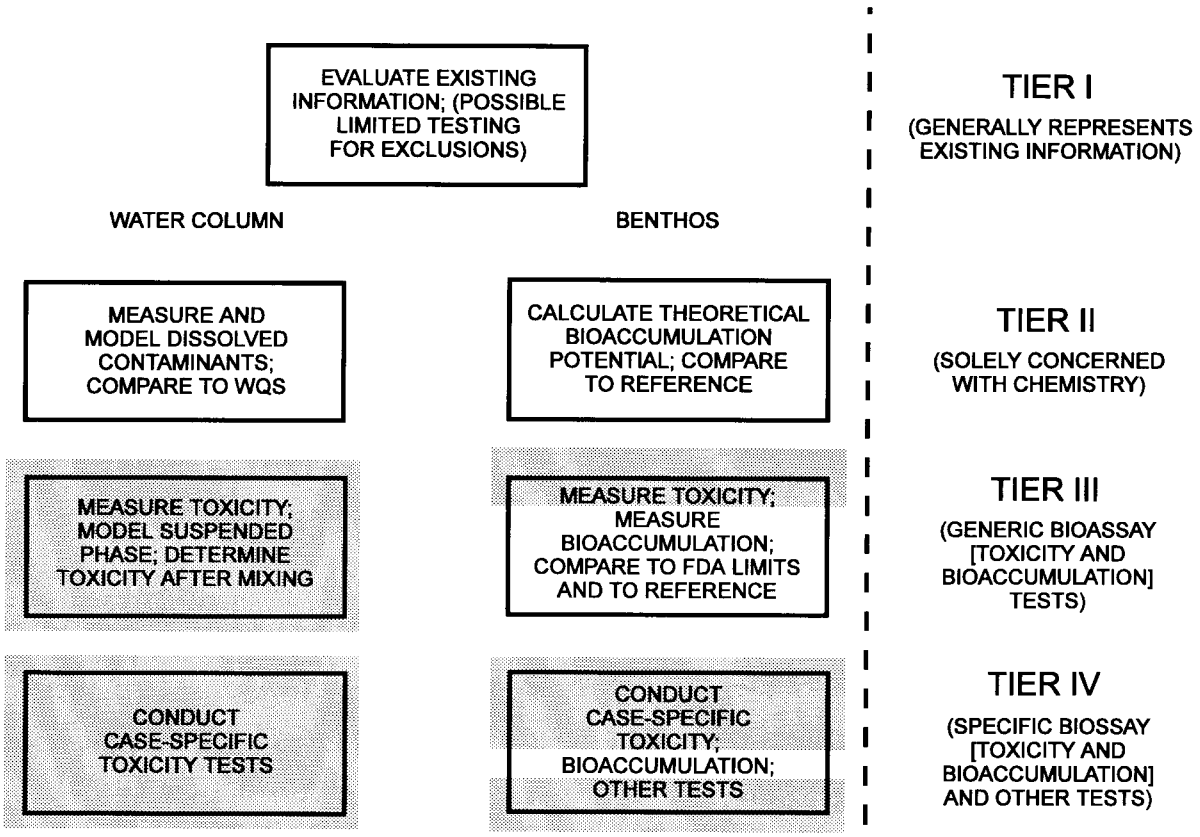
C_s = concentration of nonpolar organic chemical in the dredged material or reference sediment (any units of concentration may be used);

BSAF = 4 (Ankley et al., 1992c)

%TOC = total organic carbon content of the dredged material or reference sediment expressed as a decimal fraction (i.e., 2% = 0.02); and

%L = organism lipid content expressed as a decimal fraction (i.e., 3% = 0.03) of whole-body wet weight.

This calculation is based on work by McFarland and Clarke (1987).


EVALUATE EXISTING INFORMATION; (POSSIBLE LIMITED TESTING FOR EXCLUSIONS)
TIER I
(GENERALLY REPRESENTS EXISTING INFORMATION)
WATER COLUMN
BENTHOS
MEASURE AND MODEL DISSOLVED CONTAMINANTS; COMPARE TO WQS
CALCULATE THEORETICAL BIOACCUMULATION POTENTIAL; COMPARE TO REFERENCE
TIER II
(SOLELY CONCERNED WITH CHEMISTRY)
MEASURE TOXICITY; MODEL SUSPENDED PHASE; DETERMINE TOXICITY AFTER MIXING
MEASURE TOXICITY; MEASURE BIOACCUMULATION; COMPARE TO FDA LIMITS AND TO REFERENCE
TIER III
(GENERIC BIOASSAY [TOXICITY AND BIOACCUMULATION] TESTS)
CONDUCT CASE-SPECIFIC TOXICITY TESTS
CONDUCT CASE-SPECIFIC TOXICITY; BIOACCUMULATION; OTHER TESTS
TIER IV
(SPECIFIC BIOSSAY [TOXICITY AND BIOACCUMULATION] AND OTHER TESTS)